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Teatime on Mount Kilimanjaro: Assessing climate and land-use effects on litter decomposition and stabilization using the Tea Bag Index

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Abstract

Copyright © 2018 John Wiley & Sons, Ltd. Decomposition is one of the most important processes in ecosystem carbon (C) and nutrient cycles and is a major factor controlling ecosystem functions. The functioning of Afromontane ecosystems and their ability to provide ecosystem services are particularly threatened by climate and land-use change. Our objectives were to assess the effects of climatic conditions (elevation and seasonality) and land-use intensity on litter decomposition and C stabilization in 10 ecosystems along the unique 3,000-m elevation gradient of Mt. Kilimanjaro. Tea Bag Index parameters (decomposition-rate-constant k and stabilization-factor S) were used to quantify decomposition of standardized litter substrate. Nine pairs of tea bags (green and rooibos tea) were exposed in each ecosystem during the short-wet, warm-dry, long-wet and cold-dry season. Decomposition rate increased from k = 0.007 in savanna (SAV; 950-m elevation), up to a maximum of k = 0.022 in montane cloud forest (2,100 m). This was followed by a 50% decrease in (sub-)alpine ecosystems (>4,000 m). SAV experienced the strongest seasonal variation, with 23-times higher S values in dry season compared with wet season. The conversion of SAV to maize monocultures (~1,000 m) and traditional agroforestry to large-scale coffee plantations (~1,300 m) increased mean k values, and stabilization factors were about one-third lower. Forests between 1,900 and 2,100 m represent the zone of sufficient moisture and optimal temperature conditions. Seasonal moisture (lower slope) and temperature limitation (alpine zone) decreases litter decomposition. Mt. Kilimanjaro ecosystems are highly sensitive to land-use change, which accelerates ecosystem cycles and decreases C stabilization.

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Keywords

carbon cycle, East Africa, elevation gradient, land-use change, Tea Bag Index, tropical mountain forest

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